Alberta Energy Regulator

# Directive 085

**Release date: July 14, 2016**
**Effective date: July 14, 2016**

## Fluid Tailings Management for Oil Sands Mining Projects

The Alberta Energy Regulator has approved this directive on December 17, 2015.

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President and CEO

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## 1 Introduction

This directive, under the *Oil Sands Conservation Act* (*OSCA*), sets out requirements for managing **fluid tailings**[1] volumes for oil sands mining **projects**, including application information requirements, the application review process, fluid tailing management reporting, and the surveillance and compliance process. Fluid **tailings** dam or impoundment requirements, applications, and performance reports are managed through part 6 of the *Water Act*.

This directive replaces *Directive 074: Tailings Performance Criteria and Requirements for Oil Sands Mining Schemes*, aligns with the *Lower Athabasca Regional Plan* (*LARP*), and enables the implementation of the *Tailings Management Framework for the Mineable Athabasca Oil Sands* (*TMF*).

*LARP* establishes resource and environmental management outcomes for air, land, water, and biodiversity and guides future resource decisions. *LARP* required the development of policy direction to manage fluid tailings from oil sands mining projects. The *TMF* provides policy direction to the AER to manage fluid tailings volumes during and after mine operation in order to manage and decrease liability and environmental risk resulting from the accumulation of fluid tailings on the landscape. The objective of *TMF* is to minimize fluid tailings accumulation by ensuring that fluid tailings are treated and reclaimed progressively during the life of a project and that all fluid tailings associated with a project are **ready to reclaim** (RTR) ten years after the **end of mine life** of that project. The objective will be achieved while balancing environmental, social, and economic needs.

As this directive is closely aligned and dependent upon the *TMF*, stakeholders should refer to both documents for a full understanding of the policy direction governing fluid tailings management in Alberta. The *TMF* is available on the Government of Alberta's website.

The 2016 version of this directive will be completed and enhanced in 2017.

The *TMF* is intended to be reviewed every five years. The Government of Alberta will ensure alignment with other policies that are developed or revised and reflect changes in information, knowledge, and continuing work on fluid tailings **indicators**. This directive will be revised as necessary to ensure it appropriately enables and aligns with changes in the *TMF* and other government policy.

In addition, the AER will continually improve the directive based on observations as to the effectiveness of the requirements and feedback from stakeholders.

[1] Terms set in bold are defined in the glossary. They are only bolded at first use.

The AER would like to acknowledge the Tailings Regulatory Management Technical Advisory Committee (TAC) for their input to this directive. TAC is a multistakeholder committee consisting of participants representing environmental nongovernmental organizations, First Nations, industry, Métis organizations, the municipality of Wood Buffalo, and the regulator.

### 1.1 AER Requirements

Following AER requirements is mandatory for the responsible duty holder as specified in legislation (e.g., licensee, operator, company, applicant, approval holder, or permit holder). The term "must" indicates a requirement, while terms such as "recommends" and "expects" indicate a recommended practice.

Each AER requirement is numbered.

Information on compliance and enforcement can be found on the AER website.

## 2 AER Approach

This directive uses an outcome- and risk-based approach to holding operators accountable for managing their fluid tailings. In this approach, the AER is not establishing uniform requirements, but is instead requiring that operators identify optimum solutions for their project-specific fluid tailings management that meet the *TMF* objective and outcomes.

At the highest level, the AER approach can be described as follows:

- Proponents are required to submit applications (refer to section 4) for approval under section 10 (for new projects) or section 13 (for approved project) of the *Oil Sands Conservation Act* (*OSCA*) that include **fluid tailings volume profiles** (often referred to as "profiles") and a fluid tailings management plan for new and legacy fluid tailings. Initial fluid tailings volume profiles and fluid tailings management plans are applications under *Responsible Energy Develop Act* (*REDA*). The fluid tailings management plan must demonstrate that the profiles are consistent with the *TMF* profile guidelines, and that the project and individual deposits meet the *TMF* objective and outcomes.
- If the **fluid tailings volume profiles** and fluid tailings management plan are approved, the AER will set **thresholds** suited to the accepted profile, adhering to the *TMF* policy. The AER will amend, as appropriate, existing approvals under the *Environmental Protection and Enhancement Act* (*EPEA*) and the *OSCA* to include project-specific site-wide and individual deposit fluid tailings management requirements and conditions of approval. The profiles, plans, thresholds, and conditions of approval are collectively used by the AER to hold operators accountable for their fluid tailings management plans and monitoring programs.
- Operators are required to report annually on the performance of their fluid tailings management

plans, including **fluid tailings inventories**, continuous improvement, and development of technologies and environmental monitoring results (refer to section 5). Each year's actual volume of fluid tailings must be within an operator's approved fluid tailings volume profiles.

- If fluid tailings volumes increase beyond a threshold or deposits are not meeting the proposed performance **criteria**, operators will take measures to resolve the issue. As well, when a threshold is exceeded, the AER will initiate a management response (refer to section 11), choosing from a range of increasingly severe regulatory and financial tools, including increased reporting requirements, increased surveillance, action under the Mine Financial Security Program, third-party audits, production curtailment, or penalties.
- An operator's profiles and the fluid tailings management plan are reviewed by the AER every five years, or as necessary, to ensure that profiles and thresholds are in line with projections and policy and that they reflect current technology, new knowledge, and continuous improvement.
- The AER will prepare an annual performance report on fluid tailings management and make it publicly available, including on its website.
- As per the *Oil Sands Conservation Rules* (*OSCR*), the AER will make all fluid-tailings-related documents (applications, submissions, reports) publicly available, including on its website, to ensure that stakeholders have access to regulatory information about fluid tailings management.

The AER's 2014-2017 strategic plan describes its commitment to pursuing opportunities to improve environmental performance of tailings management, with a goal of reducing the environmental footprint of tailings and ultimately ensuring that the land can be reclaimed. The AER will report on progress made in managing fluid tailings volumes in its annual reports.

## 2.1 Fluid Tailings Profiles and Thresholds

The AER will evaluate the proposed fluid tailings volume profiles recognizing that a number of factors affect an operator's accumulation of fluid tailings, or fluid tailings inventory—for example, mine plan and bitumen production levels, geology and geography, mining and extraction processes, and fluid tailings treatment processes and other social, economic and environmental factors. These factors inform the development of unique fluid tailings volume profiles that forecast new and legacy fluid tailings accumulation and reduction. The profiles represent the volume of fluid tailings over time on the project site that is not meeting the RTR performance criteria. The *TMF* specifies that **new fluid tailings** from the project must be RTR ten years after the end of mine life, while all legacy tailings must be RTR by the end of mine life.

The AER will set project-specific thresholds based on the project-specific end-of-mine-life fluid tailings volume target, which is a volume of fluid tailings that can be managed to a RTR state within ten years after the end of mine life. The profiles and this end-of-mine-life fluid tailings volume target inform the AER's development of the **profile deviation trigger**, the **total volume**

**trigger**, and the **total volume limit**, collectively referred to as **thresholds**. The thresholds inform when the AER will initiate management responses so that fluid tailings do not accumulate beyond a volume or at a rate that precludes operators from meeting RTR status ten years after the end of mine life.

The *TMF* identifies the following considerations for establishing profiles:

- An assumption of progressive treatment of fluid tailings throughout the life of a project.
- Accumulation at the end of mine life is within a manageable range or volume that can be reduced to a RTR state within ten years. It is not intended to discourage smaller volumes on the landscape at the end of mine life.
- Existing projects may accumulate some additional fluid tailings, but they must demonstrate fluid tailings treatment is continuing.
- All plans should be based on the most advanced and demonstrated technologies. Where there are uncertainties within the chosen tailings technologies, the plans will identify contingency plans to manage risk.
- Fluid tailings must be managed and minimized through the life of the project, including during production expansion. As production increases, additional accumulation of fluid tailings must be managed while ensuring that long-term closure and reclamation goals are met. With significant increases in production, increases in fluid tailings treatment capacity will be made to ensure managed accumulation of fluid tailings during expansion phases.
- Tailings management plans will result in a safe, stable, and sustainable final landscape.

## 3 Principles

The key principles in employing the AER's regulatory approach include the following:

- Align with existing Government of Alberta legislation, regulations, and policies
  - The directive aligns with *TMF* and other policies.
  - The directive builds on existing legislation, regulations, and requirements.
- Clearly communicates
  - The directive supports long-term certainty in the regulatory process. It provides clarity for industry and stakeholders early in the design cycle about operating requirements for fluid tailings management over the life of the project.
- Consider the net environmental effect of tailings management
  - Potential consequences to air, land and its use, water, and the ecosystem will be considered and balanced.

  - The net environmental effect of tailings management technologies will be considered.
- Holistic approach to tailings management
  - The directive provides sufficient flexibility to support site-specific optimization of tailings management planning and mine operation to maximize the opportunities for responsible and sustainable resource development.
- Incorporates continuous improvement and considers timeliness, flexibility, and adaptability
  - The directive recognizes that scientific understanding, technology, and performance **measures** will change over time, and that flexibility and adaptability are needed to ensure that desired social, economic, and environmental outcomes continue to be achieved.
  - The directive must consider the unique features of every project.
  - The directive will be reviewed and updated to ensure alignment with the *TMF* and other directives that are developed or revised.
- Manage and decrease risk
  - The directive is designed to lower environmental and other risk to all stakeholders and the province during mine operations and closure.
  - The directive seeks to minimize the liability associated with accumulation of fluid tailings to the province and all Albertans, First Nations, and Métis, by requiring progressive treatment and reclamation over the life of the project.
  - The directive manages liability with the use of financial backstops.
- Manage both new and existing (legacy) tailings
  - The directive addresses fluid tailings from ongoing bitumen production, as well as the current inventory of fluid tailings **(legacy tailings)**.
- Pursue cost-effective solutions
  - In addition to environmental and social considerations, success at the operational level requires that cost-effective solutions be developed and pursued.
- Shared responsibility
  - Industry and the AER share the responsibility for tailings management. The AER intends to continue to engage stakeholders, First Nations, and Métis organizations and working groups who live and work in the area as the directive is developed and implemented.
- Support enforceability
  - The requirements in the directive will be clear and enforceable.

- Technological innovation
  - The directive supports technological innovation, understanding, and certainty around fluid tailings treatment options.
- Transparency
  - The directive recognizes the need for increased transparency between the AER, industry, Albertans, First Nations, and Métis, regarding tailings management.
  - The directive is intended to enhance transparency through increased monitoring, evaluation, and reporting requirements to provide Albertans, First Nations, and Métis assurance that fluid tailings are being managed responsibly. This necessitates the involvement of others in activities such as the evaluation of fluid tailings profiles and thresholds, monitoring, reporting, and the review of the directive.

## 4 Profiles and Fluid Tailings Management Plan Application Requirements

### 4.1 Introduction

Profiles and fluid tailings management plans must demonstrate alignment with the intent and outcomes of the *TMF*.

All existing fluid tailings management plans and approvals for oil sands mining projects will require changes to ensure that the intended outcomes are met. Operators are accountable for filing applications under the *OSCA* to amend existing approvals that show how their fluid tailings management profiles and plans meet the intent of the *TMF*'s intended outcomes. The level of detail necessary in an amendment application will vary depending on the nature of the changes in an operator's fluid tailings management plan.

Mineable oil sands applications for new projects or projects currently under review by the AER will need to demonstrate that the requirements of this directive have been met as a part of that application.

*OSCA* applications for fluid tailings management plans will

- build on existing application processes and existing approval conditions where appropriate;
- describe the fluid tailings management plan for the life of the project to provide assurance that *TMF* outcomes can be achieved and that environmental, social, and economic needs have been balanced;
- for already approved projects, identify changes to the approved project, either under the *OSCA*, *EPEA*, or the *Water Act*, and describe the potential benefits and impacts of the change;

- convey a full understanding to support a public review of the fluid tailings management plan, its outcomes, risks, and measures that will mitigate those risks;
- identify individual fluid tailings deposits and associated performance and milestones;
- identify operators' commitments to fluid tailings management and progressive reclamation;
- provide clear rationale to support conclusions;
- provide data to support justifications;
- describe assumptions used to support analysis and models; and
- show commitment to innovation and continuous improvement.

If approved, fluid tailings management profiles and plans support the development of approval conditions and the compliance and surveillance process. The AER will amend existing approvals under *EPEA* and the *OSCA*, as appropriate, to include project-specific site-wide and individual deposit fluid tailings management requirements. In approving applications, the AER is approving the proposed fluid tailings management profile and plan and the commitments made within the application. The AER will clearly identify any areas in the applications where approval is not granted. The AER will include conditions in approvals that are outcomes based, manage risk and uncertainties, support flexibility and adaptive management, and are enforceable. The AER will build on approval conditions, where they exist, with respect to research and monitoring programs. At a minimum, approval conditions will address

- project-specific thresholds for both new and legacy fluid tailings,
- fluid tailings deposit performance and milestones,
- mitigation measures and contingency plans, and
- monitoring and reporting requirements.

## 4.2 Application Process

### 4.2.1 Preapplication Considerations

Applicants are encouraged to discuss with the AER any uncertainties regarding the content or structure of an application. Applicants are encouraged to meet with the AER before filing a fluid tailings management plan application in order to

- give the AER an overview of the type and complexity of the application that will be forthcoming, and
- ask questions, identify issues, and receive clarification so that a complete application may be submitted and subsequently reviewed in a timely and efficient manner.

### 4.2.2 Application Process Requirements

1) Proponents are required to submit applications for fluid tailings management plans, for approval under section 10 (for new projects) or section 13 (for approved project) of the *OSCA*. Operators of oil sands mining projects operating as of the effective date of this directive must submit an amendment application to the AER by November 1, 2016.

2) Operators of oil sands mining projects that are approved but not yet operating must submit an amendment application at least one year before bitumen production begins.

3) Proponents of oil sands mining projects currently under review by the AER must demonstrate that the requirements of this directive have been met.

4) Proponents of new oil sands mining project applications must include anything required by this directive.

### 4.2.3 Submission Method and Format

Applications must be submitted in electronic format. The applications documents must be submitted as unlocked, searchable, and indexed files that do not exceed 200 megabytes (MB).

### 4.2.4 Application Review Process

The AER will follow the established *REDA* application review process (http://www.aer.ca/applications-and-notices/application-process). This process will be supplemented as appropriate. The application review will ensure that *TMF* transparency expectations are met.

When an application is filed with the AER, it is registered and given an application number. As per *REDA*, a copy of the application, any subsequent submissions, and AER correspondence related to it will be made publicly available, including on the AER's website.

The application will undergo a preliminary review before the AER proceeds with a detailed technical review. If necessary, the AER will send the applicant supplemental information requests to clarify issues or obtain additional information necessary to support the application. The AER may approve the application with conditions or deny the application.

### 4.2.5 Incomplete Applications

The AER may decide to close or delay an application if the fluid tailings management plan is deficient or omits any of the information required, given the stage the project is at in its life cycle. The AER understands that for projects in the early stages of operations, certain details may not be available. As a project approaches specific project milestones, and the end of mine life, approval conditions will require subsequent submissions with more detailed information.

If the AER closes or denies a deficient or incomplete application, it will notify the applicant and provide its reasoning. The applicant must reapply by submitting a new, complete application.

### 4.2.6 Amendments

Depending on the conditions of approval and the scope of proposed changes, amendment applications may be necessary. Situations in which amendment applications require applicants to conduct effective stakeholder engagement include

- when there are changes to the end-of-mine-life date affect thresholds, and
- when there are changes to the fluid tailings management plan affect thresholds or increase risk.

The AER recognizes that a fluid tailings management plan may include other plans to collect information and to develop knowledge necessary for successful implementation. The AER may make the submission of these other plans conditions of approval, meaning that amendment applications may not be required for adaptations to the fluid tailings management plan in response to new information.

When an AER management response is necessary and management actions include an operator modifying its fluid tailings management plan, an amendment application may be required.

Future modifications to mine operations necessary to manage the fluid tailings as identified in the fluid tailings management plan may require future applications to amend *EPEA*, *OSCA*, and *Water Act* approvals in order to manage risks more thoroughly and establish appropriate new requirements. The approval of the fluid tailings management plan will not constrain the AER's decision-making on future applications.

## 4.3 General Requirements

5) The application must include sufficient information to demonstrate that the fluid tailings management plan is aligned with existing approvals and plans, such as

   a) current approvals under *EPEA*, the *OSCA*, and the *Water Act*;

   b) the mine plan;

   c) the water management plan;

   d) the mine reclamation plan; and

   e) the life-of-mine closure plan.

6) The applicant must identify inconsistencies between the proposed fluid tailings management plan and current approvals and conditions. Where there isn't alignment, there must be a description of how alignment will be achieved.

7) The applicant must submit a concordance table that references where each requirement in this directive is addressed in the application.

## 4.4 Fluid Tailings Inventory Profiles

### Issue

New and legacy fluid tailings must be treated and progressively reclaimed during the life of the project, with all fluid tailings RTR ten years after the end of mine life. The *TMF* provides fluid tailings inventory profile guidelines that operators must consider in the development of their fluid tailings management plans, including the following:

- **Early production:** To achieve the **end-of-mine-life target**, it is expected that projects manage the inventory of new fluid tailings in the range of the volume that is expected to be produced during three to ten years of full production.
- **Design operation:** To achieve a relatively stable fluid inventory, it is expected that growth of fluid tailings will closely match the rate of treatment so that, on average, **fines** can be managed to a treated state as they are produced. This requires increases in fluid tailings treatment capacity as project expansions occur.
- **Legacy tailings: Legacy equivalent volumes** will be reduced to achieve a RTR state by end of mine life.
- **Post end of mine life:** The end-of-mine-life target for all projects will be the equivalent of five years or less of fluid tailings volume accumulation. Operations are required to achieve RTR state ten years after end of mine life.

### Requirements

8) The fluid tailings management plan must provide sufficient information to support the proposed new and legacy fluid tailings volume profiles, including
   a) a fluid tailings volume profile for new fluid tailings in graphical and table format;
   b) a fluid tailings volume profile for legacy equivalent fluid tailings in graphical and table format;
   c) explanation of the factors that contributed to choosing the proposed end-of-mine-life date;
   d) justification for the proposed legacy and new volume profiles, including
      i) justification for the volume of fluid fine tailings in the inventory at the end of mine life,
      ii) justification for the rate and magnitude of accumulation of new fluid tailings after 2015, and

iii) if required, a justification for any deviations from the *TMF* tailings inventory profiles guidelines;

e) justification for prioritizing the sequence of treating fluid tailings and where deposition is planned, including the rationale for when legacy equivalent tailings will be treated;

f) a high-level description of mining and processing operations to provide context for the fluid tailings management plan;

g) explanation of how capacity will be available to hold water and fluid tailings within the on-site closed-circuit water system for the life of the project (if not, then identify the magnitude and timing of storage limitations);

h) assumed annual ore processing rate and composition;

i) a graph of bitumen production and new fluid tailings generation over the life of the project;

j) status maps (beginning, milestones, and end) identifying the location and size of treated tailings deposits and fluid tailings ponds, both existing and proposed, in the mine area (maps must clearly illustrate the progression of the treated tailings deposits and fluid tailings ponds until ten years after the end of mine life);

k) tables that show the predicted annual volume of each fluid tailings pond and treated tailings deposit over the life of the mine and ten years after and that indicate both legacy equivalent and new fluid tailings volumes, including

   i) the annual volume of fluid tailings, annual fluid tailings deemed RTR, and water, including any assumptions of reduction in volume due to factors such as consolidation;

   ii) predicted annual volume of fluid tailings treated for each fluid tailings treatment technology; and

   iii) a composition at the beginning, milestones, and end for each fluid tailings pond and treated tailings deposit;

l) a process flow diagram that indicates the current typical calendar-day volume and mass balance (around treatment process, fluid tailings ponds, and treated tailings deposits) including stream compositions—that is, oil, water, and solids—and the volume of water recovered from treatment of fluid tailings and treated tailings deposits; and

m) an update of the above-mentioned diagram for predicted changes in annual volumes and mass balance that represent significant changes in the project, including the volume of water recovered from treatment of fluid tailings and treated tailings deposits.

## 4.5 Legacy Tailings Inventory

### Issue

The determination of legacy tailing volumes for each project.

### Requirements

9) Applications must include legacy tailings volume information as of January 1, 2015, for the project, including the

   a) location of all legacy tailings on a figure/map of the entire mine site;

   b) volumes of legacy tailings, as measured by the set of techniques described in section 8;

   c) composition of each legacy tailings deposit and pond (this could include cross-sections for deposit with varied compositions);

   d) location and volume of legacy tailings that meet RTR status for removal from the fluid tailings inventory (describe and justify the indicators, measures, and criteria used to determine whether the volume has achieved RTR status);

   e) volume of water contained in each fluid tailings pond and treated tailings deposit; and

   f) characterization of the water quality, including chemical properties, in each fluid tailings pond and treated tailings deposit (describe the methods used in characterization).

## 4.6 Fluid Tailings Treatment Technologies

### Issue

The risks, benefits, and trade-offs associated with the proposed technology must be understood, have contingencies identified, and risks mitigated. Technology includes the associated infrastructure such as the transport of fluid or treated tailings.

### Requirements

10) Applicants must justify that the technologies proposed are the best available for the project and provide sufficient information for the AER to assess the appropriateness of the technologies chosen. The details required for each technology include

   a) a map identifying proposed treatment areas;

   b) a description of the technology, including its **robustness**, practicality, and stage of development (bench scale, field pilot, prototype, commercial demonstration);

   c) timing and milestones to apply each technology;

   d) a process flow diagram;

e) chemical and physical properties of the treated tailings and the quality of water recovered from treatment; and

f) how off-spec material will be managed.

11) Where there are uncertainties with the chosen fluid tailings treatment technologies, the fluid tailings management plan must identify mitigation measures and contingency plans to manage poor performance. It must describe the uncertainties (nature and magnitude) associated with the technology. If a high level of uncertainty is identified, the following must be provided:

a) A description of the implications of technology failures for each type of uncertainty

b) Identification of and justification for mitigation measures and contingency plans for how the uncertainties will be addressed

c) Identification of and justification for the **triggers** that will be used to initiate each mitigation measure and contingency plan

d) Expected timeline of development milestones if the proposed technology is uncertain due to the early stage of its development, which must include criteria for success and a description of how their achievement will impact the profiles (as the project moves closer to the end of mine life, the level of certainty with proposed technology must increase accordingly)

12) In cases where water-capped fluid tailings technology is used to generate the inventory forecast in the profiles, an alternative treatment technology to treat equivalent volumes of fluid tailings with associated implementation timeframes must be provided.

## 4.7 Ready to Reclaim

### Issue

Fluid tailings are considered RTR when they have been processed with an accepted technology, placed in their final landscape position, and meet performance criteria. RTR is intended to track treated fluid tailings performance during the operational stage of the deposit to ensure that the deposit can be reclaimed as predicted in the life-of-mine closure plan, in the time predicted.

In order to evaluate whether active treated tailings deposits are on the predicted trajectory to allow them to be removed from the fluid tailing inventory, they must achieve approved performance criteria. Each treated tailings deposit will have approved indicators that must be measured to determine if the performance criteria has been achieved.

### Requirements

The application must include information to support the assessment of proposed performance criteria, which establishes when a deposit meets RTR status (refer to section 10 for further

information on RTR status). The AER understands that for projects in the early stages of operations, certain details may not be available; however, before depositing treated tailings, conditions of approval will require that more detailed information be provided.

13) The application must provide the following at a level of detail commensurate with the stage of operation:

a) A map showing the location and size of treated tailings deposits and fluid tailings ponds, both existing and proposed, in the mine area.

i) For deposits currently operating, the maps must clearly illustrate the targeted final landforms and the targeted range of ecosites.

ii) For proposed deposits, a map or table that describes the targeted range of ecosites that can be described by site-type or moisture regime must be provided.

b) Identification and justification for the proposed indicators for each deposit. Where indicators are presented as part of a set, the set should be coherent and balanced. Justify any change in indicators through the life of the deposit. Show how the following are considered:

i) Relevance: there is a clear relationship between the indicator and the **subobjective**.

ii) Importance and usefulness: the indicator tracks performance of a critical variable in the success of meeting the subobjective.

iii) Feasibility: reliable measures (data) can be obtained with reasonable and affordable effort.

iv) Credibility: the indicator is widely accepted or is recognized by the AER.

v) Validity: to the extent possible, the indicator has been field-tested or used in practice.

vi) Distinctiveness: the indicator is not redundant—that is, it does not measure something already captured under other indicators.

c) A description of the measurement plan, and associated uncertainties, selected to evaluate the indicators.

d) For each deposit, the performance criteria must be identified and how it will meet the subobjectives of RTR status explained (refer to section 10), including ensuring that the deposit's physical properties (subobjective 1) are on a trajectory to support future stages of activity and that the effects the deposit have on the surrounding environment (subobjective 2) are minimized and will not compromise the ability to reclaim to a diverse, locally common, and self-sustaining ecosystem. To demonstrate this, include at least the following:

i) assessment of the risk of environmental effects in the area surrounding the treated tailings deposit, including impact to groundwater, surface water bodies, seepage, stability, erosion;

ii) potential deposit design features to mitigate risks associated with fluid tailings deposition, treatment, and water recovered from treated fluid tailings (such as seepage barriers); and

iii) case-by-case risk analysis to identify performance measures and criteria to demonstrate the effectiveness of design features. If an applicant does not recommend indicators or measures for specific design features, they must describe how they will ensure the subobjective is met and why monitoring of these specific design features is unnecessary.

e) For currently operating deposits, justification of how the proposed RTR indicators and performance criteria for subobjectives align with the targeted final landforms and the targeted range of ecosites. For proposed deposits, targeted range of ecosites can be described by using site-type or moisture regime. (The information could be presented in tabular format.)

f) Identification of critical milestones for each deposit including deposit preparation, start of fluid tailings placement, capping, and start of further **reclamation activities**.

g) Identification of uncertainties (nature and magnitude) associated with deposit performance and design features that mitigate deposit effects to the surrounding environment. If a high level of uncertainty is identified, describe

i) the nature of the uncertainty and the impact of associated failures and

ii) plans to mitigate uncertainty, including additional research, testing, and potential contingency plans if performance is not as predicted.

h) A description of how the operator will ensure long-term data accessibility and quality for the life of the project.

## 4.8 Environmental Effects and Implications

### Issue

The *TMF* objective is to minimize fluid tailings accumulation, which may reduce environment effects such as a reduction in seepage, occurrences of wildlife contact with tailings ponds, and tailings footprint.

However, efforts to minimize fluid tailings volumes may result in potential changes or trade-offs to other environmental risks and effects to air, land and water. These changes or trade-offs must be

identified and their short-term and long-term implications to environmental performance assessed. Applications will identify the nature, including location, and magnitude of environmental effects and the understanding of their environmental and reclamation implications.

For currently approved projects, the proposed fluid tailings management plan should be consistent with the previously predicted environmental outcomes or identify any inconsistencies. The existing and proposed monitoring plans will confirm that environmental performance is achieved.

The fluid tailings management plans must align with existing provincial and federal policies, legislation, regulations, strategies, frameworks, requirements, and stated desired outcomes for the region.

Fluid tailings management plans, including mitigation measures and contingency plans, will minimize the risk of environmental effects over the life of a project.

### Requirements

14) The application must describe (nature and magnitude) the environmental effects and risks of environmental effects of the proposed management option, including for each fluid tailings pond, treatment area, and treated tailings deposit. In addition, describe

    a) how they will be managed or mitigated during operations, reclamation, and closure;

    b) changes to or additional pollution prevention and mitigation measures necessary to reduce environment effects of the proposed option; and

    c) changes in local circumstances, policies, or regional initiatives that need to be addressed.

15) For each alternative management option (refer to section 4.5) include an evaluation (including nature and magnitude) of

    a) for currently approved projects, the changes in environmental effects and risks of environmental effects from current state for each treated tailings deposit, treatment area, and fluid tailings pond;

    b) for new projects, the environmental effects and risks of environmental effects of each treated tailings deposit, treatment area and fluid tailings pond;

    c) the justification of the trade-offs between the management options(including proposed); and

    d) the environmental and reclamation implications related to the change in environmental effects, such as implications for wildlife and land access.

    The fluid tailings management plan may reference existing documents or approval requirements, if appropriate.

16) The fluid tailings management plan must describe uncertainties (nature and magnitude) associated with the environmental effects and mitigation measures during operation, reclamation, and closure stages. If there is a high level of uncertainty, describe

    a) the nature of the uncertainty and the impact of associated failures,

    b) mitigation measures or contingency plans for how the uncertainties will be addressed, and

    c) timelines and milestones for fluid tailings research to address uncertainties.

17) The application must identify proposed changes to environmental monitoring and performance measures.

# 5 Fluid Tailings Management Reporting

## 5.1 Introduction

The AER requires an operator to provide performance data, information, and analysis to verify that it is following its fluid tailings management plan, profiles, and conditions of approval. This information will provide the basis of the AER surveillance and enforcement processes (further described in section 11) and inform the AER's decision regarding a management or enforcement response.

The annual fluid tailings management reports will provide information for the following purposes:

- to verify that an operator is implementing its approved fluid tailings management plan, including confirmation that stated milestones are being achieved;
- to verify that an operator's fluid tailings performance is in accordance with its profiles;
- to verify that fluid tailing deposits are meeting RTR performance criteria and are on the applicable trajectory;
- when fluid tailings volumes exceed thresholds or the total volume limit, to inform the AER's decision regarding an appropriate management response;
- to monitor the performance of fluid tailings treatment technologies;
- to support the AER's annual summary report that will include the fluid tailings volumes in the region, total volume of fluid tailings treated, the amount of fines captured and describe management actions taken to improve performance;
- to support regional reporting; and
- to support future *TMF* and five-year plan reviews.

As per the *OSCR*, the annual operator fluid tailing management reports will be made publicly available, including on the AER's website by June 30. The AER will create a summary

performance report in a timely manner and it will also be made publicly available. The AER will consider opportunities to enhance stakeholder and public understanding of the fluid tailing management reports.

## 5.2 Fluid Tailings Management Report Requirements

18) Operators must submit annual management reports to the AER by April 30 for the previous year's performance (January to December), in electronic format. It must include the following sections and information.

**Executive Summary**

An operator must submit a summary of fluid tailings management activities during the reporting period, including fluid tailings treatment and placement operations (showing alignment with the reclamation plan), technology development, and contingency or mitigation actions initiated in response to fluid tailings volume profile deviations or threshold exceedance, if any.

**Fluid Tailings Volume Reporting Requirements**

- Include a project site summary of all annual fluid tailings volumes, as per the accounting table in appendix 3.
- Show in a figure the approved new and legacy profiles with the actual fluid tailings volume and the three thresholds (profile deviation, total volume, and total volume limit).
- Describe if and how activities have deviated from the fluid tailings management plan and any modifications made to improve performance.
- Identify the management level (as described in the *TMF*) that the operation's performance falls within.
- If the operation is deemed level 2 or higher, describe the circumstances that led to the increased fluid accumulation and any actions that are being taken to improve fluid tailings management performance.
- Provide a site-wide water balance or provide the reference to another AER report and location where this information can be obtained.
- Provide a water volume (in tabular form) or provide the reference to another AER report and location where this information can be obtained. The table must include, for each treated tailings deposit and fluid tailings pond,
  - total volume of water at the beginning of the reporting period,
  - total volume of water at the end of the reporting period,
  - characterization of the quality of water, and

  - the volume and quality of water recovered from fluid tailings and runoff from RTR tailings,
- Provide information about fines that were not captured, which form fluid tailings, including
  - quantity of fines in the ore processed during the reporting period, and
  - quantity of fines in fluid tailings.
- Estimate the change in fluid tailings volume inventory as a result of settling and consolidation and provide an explanation if inconsistent with the predictions.
- Provide a status map of the current locations and sizes of all fluid tailings ponds and treated deposits for the project.
- Provide tables indicating the volume and composition of each deposit containing fluid tailings (including the volume of fluid tailings, of treated and placed fluid tailings meeting RTR status, and of water).
- Provide tonnage of ore processed and average composition (bitumen, water, solids) or provide the reference to another AER report and location where this information can be obtained.
- For each fluid tailings treatment technology,
  - provide volume of fluid tailings treated and where they were placed;
  - provide chemical and physical properties of the treated fluid tailings and the water recovered from treatment and;
  - if the technology is not performing as predicted, provide mitigation measures to rectify performance (address any impacts on the deposit performance).

**Monitoring Reporting Data Requirements**

For each treated tailings deposit and fluid tailings ponds and their surrounding environment provide monitoring results, including the following:

- A map and tabular data showing the survey locations of tailings deposits
- Representative cross-sections to illustrate the variation of tailings characteristics
- For each deposit containing treated and placed fluid tailings,
  - the measured data on the chosen indicators and confirm performance against the chosen performance criteria;
  - for those fluid tailings deposits that have met RTR status, data to support that it is trending appropriately; and
  - confirmation that indicator and performance criteria are still appropriate or justify the need to modify them.

- Verification that the tailings deposit is meeting the milestones in the fluid tailings management plan

**Inadequate Deposit Performance**

If the deposit is under-performing so as to impact the fluid tailings volume accumulation, then

- describe the contributing causes to under-performance;
- describe mitigation and contingency plans from the fluid tailings management plan that have been implemented to manage performance;
- identify any risks that could result from additional fluid fine tailings placement in a deposit;
- confirm that the indicators, measures, and performance criteria are still acceptable in light of new factors introduced by the mitigation and contingency plans; and
- describe the impacts that tailings performance is having on the mine plan, water management plan, mine reclamation plan, and life-of-mine closure plan.

For tailings previously identified as RTR that are no longer following the trajectory or meeting performance criteria, confirm that the volume has been added to the fluid tailings volume inventory and describe the actions taken to address under-performance.

**Technology: Continuous Improvement and Development**

To assess continuous improvement and innovation, to confirm that fluid tailings treatment technologies are operating as expected, and confirm that operational issues are being managed, the management report must include the following:

- Description of the treatment technologies' operation over the reporting period, including issues that were encountered and a summary of continuous improvement activities
- Confirmation that technology development was implemented as proposed in the approved fluid tailings management plan by summarizing relevant activities in the reporting year. Confirm that technology development will continue to be implemented as stated in the approved fluid tailings management plan
- A technical report, within the constraints of proprietary information, on the progress of any pilots, prototypes, or demonstrations of fluid tailings technologies
- An assessment, within the constraints of proprietary information, of performance, successes, challenges, and implications for net environmental effects for all treatment technologies. The assessment may incorporate information references to other required reports, such as the tailings research report and groundwater monitoring report submitted under *EPEA*

### Environmental Monitoring Results

To assess operator performance in managing and minimizing environmental effects and implications associated with fluid tailings management activities, the annual management report must provide a summary of the results from environmental performance monitoring reports related to fluid tailings management activities.

Reporting under this directive does not relieve an operator from any requirements to report tailings-related environmental information in the relevant *EPEA* reports for site-wide environmental performance. Consolidation of multiple reporting requirements to the AER will be considered in future editions of this directive.

## 6 Measurement Outcomes

19) Operators must provide quality information to demonstrate fluid tailings management performance and ensure that the measurement system meets the following outcomes:

   a) Accuracy: the degree to which the measurement matches the correct value.

   b) Precision: the measure of agreement among repeated measurements of an indicator.

   c) Sensitivity: the degree of ability to discriminate differences in performance of indicators.

   d) Representativeness: the degree that the data is a suitable measure of the condition being examined.

   e) Comparability: a qualitative expression of the confidence that the quality of data is sufficient to contribute to analysis, even when measurement methods differ.

   f) Completeness: the measure of the amount of valid data not omitted.

   g) Bias: the measure of systematic distortion (error) of measurements.

20) Operators must maintain a data management system that supports the following outcomes:

   a) Verification: the process to ensure that data are evaluated for accuracy, errors, and inconsistencies after data migration is done.

   b) Validation: follows verification; a process to compare data to documented acceptance criteria.

   c) Integrity: maintaining and assuring the accuracy and consistency of data over its entire life cycle.

If an operator monitors for any substances or parameters that are the subject of monitoring requirements set out in *EPEA* approvals, the operator must use the procedures, methods, or protocols authorized in those approvals.

## 7 Five-Year Review

The AER will review profiles and the fluid tailings management plans at least every five years during project life to ensure that actual fluid tailings volume inventories are aligned with predicted profiles and that the profiles and thresholds continue to be appropriate given technology development, new knowledge, and operators' continuous improvement efforts.

The AER will provide additional information on the process for this review including stakeholder engagement in the 2017 version of this directive.

## 8 Definition and Determination of Fluid Tailings Volume

The *TMF* defines fluid tailings as any fluid discard from bitumen extraction facilities containing more than 5 mass per cent suspended solids and having less than an undrained shear strength of 5 kilopascals. The *TMF* further states that this definition of fluid tailings will be refined during the implementation of the policy.

The AER has reviewed Canada's Oil Sands Innovation Alliance's (COSIA) *Guidelines for Determining Oil Sands Fluid Tailings Volumes* (June 2015, appendix 4), which provides a standard set of practices for defining and determining fluid tailings volume. The AER has accepted that the COSIA guidelines contain an appropriate set of procedures for determining the volume of fluid tailings in treated tailings deposits and fluid tailings ponds. The Government of Alberta recognizes that the guidelines align with the *TMF* and the principle of incorporating flexibility and adaptability.

The measurement tools in the guidelines provide a fluid tailings volume that the AER considers comparable to the *TMF* definition. For the purposes of this directive, fluid tailings are determined by COSIA's set of measurement techniques.

The AER will continue to evaluate the appropriateness of the guidelines through its surveillance program and, if necessary, will refine the measurement guidelines.

## 9 End of Mine Life

The end of mine life is the year in which mining of bitumen is complete for an AER-approved mine plan (under the *OSCA*).

Each project has a forecasted end-of-mine-life date. All fluid tailings from an approved project must be RTR ten years after the end-of-mine-life date. To ensure that this objective is met, the AER sets the **end-of-mine-life target** and thresholds. The *TMF* states that the end-of-mine-life target for all projects will be the equivalent of five years or less of fluid tailings volume accumulation.

Variations of the end-of-mine-life date are expected over the life of the project, with the date becoming more certain as the project advances towards it. Variations may require an application.

When assessing the need for and merits of an application for a change to the end-of-mine-life date, the AER evaluates if

- the *TMF* principles and expectations for fluid tailings profiles are applied and
- the *TMF* goals, objectives and outcomes will be met.

When a project expands, the end-of-mine-life date may be changed. Factors in the decision to approve the change include

- integration with the existing project,
- the location of the expansion in relation to the existing project,
- overall benefits of expansion and associated risks,
- the pace of progressive reclamation at the existing site, and
- clear demonstration that sufficient treatment capacity is being implemented to manage the associated accumulation of fluid tailings.

When a project's production rate decreases significantly or approved expansions are delayed, the end-of-mine-life date may be changed. Factors in the decision to approve the change include

- reasons for production decrease and its duration,
- associated impact (if any) to tailings treatment and capacity, and
- associated impact on progressive reclamation commitments. The AER will exercise its discretion to determine whether an amendment application is required to change the end of mine life on the basis of whether the change significantly affects the ability of the operator to meet its fluid tailings management plan.

Project suspension is a recognized risk in the Mine Financial Security Program (MFSP), with money collected to manage it. If a project is suspended for a significant time, the AER will be notified and plans to manage the suspended site will be reviewed, including the management of fluid tailings ponds and deposits. An operator is still required to provide an annual management report to ensure deposits remain on the RTR trajectory. If the deposit is under-performing, then the AER will consider requiring the implementation of mitigation measures.

Processing plants (as defined by the *OSCA*) that originally processed primary extraction products or bitumen from the project may process primary extraction products or bitumen from other projects or in situ facilities. Projects associated with the processing plant would be required to continue to meet the objective of the *TMF* and their tailings treatment and reclamation commitments, even if the plants continue to operate after the end of mine life, as defined by the AER-approved mine plan, for the original project. Any continued operation of a plant at the mine/project site after end of mine

life will not allow for any deferral of activity to meet the commitments as described in the AER-approved fluid tailings management plans.

In these cases, the AER will consider the justification for the continued operation of the plant and the need for the associated infrastructure.

If the justification meets the objective of the *TMF*, the AER will amend the mine scheme approval and will issue a new processing plant approval. Other approvals may also need to be amended to reflect this change. Any new fluid tailings produced from the processing plant would be required to meet the *TMF* objective for the new project from which the bitumen was produced.

## 10 Ready to Reclaim

### 10.1 Overview

Fluid tailings are considered RTR when they have been processed with an accepted technology, placed in their final landscape position, and meet performance criteria. RTR is intended to track treated fluid tailings performance during the operational stage of the deposit to ensure that the deposit can be reclaimed as to the targeted outcomes and schedule defined in the life-of-mine closure plan. Fluid tailings must meet RTR status in order to be removed from the fluid tailings inventory. Treated tailings meeting RTR criteria enables progressive reclamation, which results in reduced liability.

### 10.2 Objective

The concept of RTR tailings supports the objective of reclaiming oil sand mining projects to a self-sustaining boreal forest ecosystem that is (1) integrated with the surrounding area and (2) consistent with the values and objectives identified in local, subregional, and regional plans.

### 10.3 Subobjectives

In order to evaluate whether active treated tailings deposits are on a trajectory to meet the high-level objective, there are two subobjectives that address different aspects of performance:

- Subobjective 1: the deposit's physical properties are on a trajectory to support future stages of activity.
- Subobjective 2: to minimize the effect the deposit has on the surrounding environment and ensure that it will not compromise the ability to reclaim to a locally common, diverse, and self-sustaining ecosystem.

Subobjective 2 focuses on circumstances where the operator may propose management strategies, design features, or mitigation measures for risks associated with the specific nature of the deposit or its surrounding environment that could impact reclamation—for example, design features that

control specific water movement such as drainage control systems, or management of risks associated with deposit characteristics such as treated froth fluid fine tailings, acidification, specific additives, or gas formation.

If appropriate, an operator may propose and justify additional subobjectives.

### 10.4 Performance Criteria

Each subobjective has at least one associated RTR performance criterion that demonstrates that the treated tailings in each deposit are on a trajectory to successfully support future stages of planned reclamation activity. RTR performance criteria will be used to determine when treated tailings are successfully progressing on a clear trajectory, from short- and medium-term outcomes towards long-term outcomes in the mine reclamation plan and life-of-mine closure plan.

The *TMF* provides the flexibility for operators to develop performance criteria that are suitable to the type of tailings, technology, and deposit. The selection of performance criteria and how they are measured depends on

- the characteristics of the deposit (technology used, properties of the treated tailings),
- the stage of the deposit in its development,
- the deposit's targeted landforms and site-type, and
- the position of the deposit in the landscape (e.g., below- or above-grade, proximity to sensitive areas or water bodies, etc.).

The AER expects that tailings deposits with higher uncertainty or more complexity, including with the surrounding environment, may have more indicators, measures, and performance criteria associated with them. These treated tailings deposits will require more stringent performance criteria and rigorous monitoring.

An example of how RTR performance criteria may be developed is provided in appendix 2.

### 10.5 Application

The application will identify and justify the relevant subobjectives, and for each deposit and the deposit's surrounding environment it will

- identify indicators that will be monitored,
- identify measures to evaluate progress on the indicators, and
- identify performance criteria, including those that progress over defined timelines.

Within the application, operators must select and justify the proposed performance criteria. The operator must demonstrate how RTR performance criteria aligns with the targeted distribution of

site-type and range of land uses identified in the life-of-mine closure plan and approved mine reclamation plan. In addition, the operator must demonstrate that the treated tailings will enable progressive reclamation during the life of the project. The proposed performance criteria must demonstrate that subobjectives continue to be met over time and ensure progression towards the deposit's intended outcomes.

The rationale for the indicators and performance criteria must explain the proposed trajectory (anticipated rate, degree, and timing of deposit performance improvement) and how it aligns with proposed **reclamation criteria**. The operator must provide evidence to substantiate the proposed performance criteria and identify uncertainties in predictions, including the major factors contributing to these uncertainties. Performance criteria will only require passive management of the deposit, such that there is minimal need to continuously manage risks. RTR performance criteria will be evaluated to ensure that they are conservative so that treated tailings deposits are not continually moving on and off of the fluid tailings volume inventory.

The application will include the rationale for any proposed changes in the indicators, measures, and performance criteria as the treated tailings deposit advances—for example, different environmental indicators may become more important and have more stringent performance criteria at different layers of the deposit, such as hydraulic connectivity or settlement.

The application will also include the details for ongoing performance monitoring systems, including an assessment of their sensitivity for the performance criteria.

The AER expects that as knowledge is gained, the performance criteria may be improved.

### 10.6 Operations

The AER will review and evaluate treated tailings performance annually. If the treated tailings are meeting the RTR performance criteria, they can be removed from the fluid tailings inventory because they are on a clear trajectory to meeting long-term reclamation outcomes. Treated tailings will require ongoing monitoring to confirm they are still on the RTR trajectory and meeting trajectory milestones. In circumstances where performance criteria are no longer met or there is a deviation from the expected trajectory, operators must identify the volume not meeting the performance criteria and the degree of nonperformance. The AER's response to not meeting the treated tailings performance criteria will depend upon the consequences associated with the nature of the subobjective not being met, the degree of nonperformance, and the effectiveness of mitigation measures or contingency plans employed by the operator. The AER's response will also consider the implications to the site-wide fluid tailings volume profiles, including the exceedance of a threshold, and will employ the level of management response measures outlined in the *TMF* and appropriate enforcement (refer to section 11).

## 10.7 Reclamation

The terms RTR (ready to reclaim) and "ready for reclamation" are different. RTR is used to track the performance of an active, operational tailings deposit. "Ready for reclamation" is used to identify the project areas (inclusive of tailings deposit areas) that are no longer operational and are available for reclamation, but where reclamation activities have not yet begun.

"Ready for reclamation" is one of eight categories used to report annually on the progress of reclamation across oil sands mines. This reporting approach is one element of the progressive reclamation strategy in *LARP*.

The figure below is a conceptual diagram representing the relationship between RTR and reclamation. It does not represent specific timelines or milestones, which will be deposit specific.

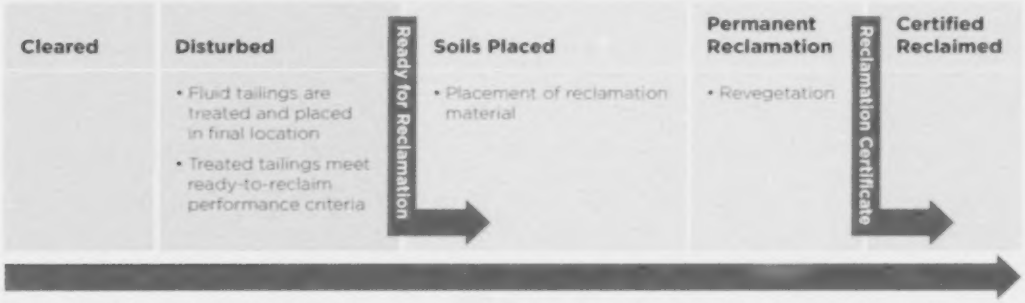


**Figure 1. Conceptual diagram of management and reclamation activities for a treated tailings deposit**

## 10.8 Clarification of Specific Circumstances

### 10.8.1 Temporary Locations

The AER recognizes that fluid tailings treated with certain technologies may be placed in a temporary location and still be able to meet RTR status—for example, in the case of thin-lift drying, where dried fluid tailings can provide a reliable source of infrastructure material or be placed in dumps. RTR performance criteria will be developed for the interim placement location, as well as for the final placement location. As well, the operator must assess the potential implications to the surrounding environment of the dried fluid tailings when they are in both the temporary and final landscape positions and (if necessary) how those risks will be managed.

### 10.8.2 Water-Capped Fluid Tailings

In an ongoing demonstration, fluid tailings have been capped with a mixture of process water and other water sources, which is eventually intended to support an aquatic ecosystem. The AER has approved a number of water-capped fluid tailings deposits conditional upon the success of project demonstrations. Industry is proposing further investigation into water-capped fluid tailings technology.

To support the assessment of water-capped fluid tailings technology, the Government of Alberta will be developing additional direction and performance criteria. Once the AER has received direction, including RTR performance criteria, from the Government of Alberta, a regulatory approach to water-capped fluid tailings will be developed. Until that time, water-capped fluid tailings technology may be used to generate the inventory forecast in the profiles provided the fluid tailings management plan includes an alternative technology option, including timeframes for implementation.

New proposals for water-capped fluid tailings must be applied for under the *OSCA* and *EPEA*.

Currently, annual fluid tailing management reports cannot remove fluid tailings volumes treated with water-cap technology from the inventories pending further direction from the Government of Alberta.

## 11 Surveillance and Compliance Process

The AER is developing requirements around the *TMF*'s management system. For now, the AER will follow the management actions described in sections 6.1 and 6.2 of the *TMF* (see figure 2).

The AER's existing compliance and enforcement tools also apply.

Any actions taken as part of the surveillance and compliance management system will be made publicly available, including on the AER website.

## 12 Mine Financial Security Program

The *TMF* requires that the MFSP be updated to support its intended use as a short-term management response for managing fluid tailings. It is expected that these changes will be included in the 2017 edition of this directive.

| Level | Potential Management Actions |
|---|---|
| Level 4 | • Operator will provide a plan and take immediate action to bring fluid tailings volumes below limit<br>• Use of any regulatory instruments including regulatory tools and enforcement actions available, depending on the circumstances. This could include the use of the highest consequence regulatory instruments (e.g. production curtailment, penalties, no new approvals)<br>• Application of regulatory financial tools including:<br>  ◦ Payment into Mine Financial Security Program<br>  ◦ Compliance levy<br>• Third-party audit<br>• Additional surveillance<br>• Communicate with stakeholders and First Nations and Métis |
| | **Total Volume Limit (140 per cent of End-of-Mine-Life Target)** |
| Level 3 | • Identify urgency of and need for additional measures<br>• Determine, for example, cause of exceedance, whether treatment capacity exists to control fluid tailings growth, and whether investment in capacity and investment in new technologies is occurring<br>• Provide action plan for approval and take action to bring below total trigger volume, if necessary<br>• Use of regulatory instruments under existing legislation and policy<br>• Depending on the nature of the exceedance, potential use of regulatory financial tools including:<br>  ◦ Action under Mine Financial Security Program<br>  ◦ Compliance levy<br>• Additional surveillance<br>• Communicate with stakeholders and First Nations and Métis |
| | **Total Volume Trigger (100 per cent of End-of-Mine-Life Target)** |
| Level 2 | • Reporting to confirm, for example, that treatment capacity exists to control fluid tailings growth, and investment in capacity and investment in new technologies is occurring<br>• Operator will provide plan and take immediate action to bring fluid tailings volumes in line with approval<br>• Application of regulatory financial tools including:<br>  ◦ Action under Mine Financial Security Program<br>  ◦ Compliance levy, as appropriate<br>• Additional surveillance<br>• Communicate with stakeholders and First Nations and Métis, as needed |
| | **Profile Deviation Trigger (Actual fluid tailings volume growth is 20 per cent higher than the approved profile)** |
| Level 1 | • Verify tailings conditions of approval are being met, including volumes and growth against profiles<br>  ◦ Track and trend available data<br>  ◦ No management actions beyond base regulatory systems |

**Figure 2. Potential management actions for each management level (from *TMF*, page 33)**

## Appendix 1 Glossary

| | |
|---|---|
| **Criteria** | A standard of judgement or criticism; a rule or principle for evaluating or testing something. A basis for judging adequacy.<br>A quantitative aspect of a measure (values) that demonstrates whether or not an objective is met or that risk of adverse effects is unacceptable or likely. |
| **End of mine life** | The year in which mining of bitumen is complete for an AER-approved mine plan. |
| **End-of-mine-life target** | A volume of fluid tailings that can be managed to a RTR (ready-to-reclaim or managed) state within ten years after end of mine life. |
| **Fines** | Solids with particle sizes equal to or less than 44 micrometres. |
| **Fluid tailings** | Refer to section 8 for the definition of fluid tailings and determination of fluid tailings volume. |
| **Fluid tailings inventory** | The volume of legacy and new fluid tailings at a project site at any given time. |
| **Fluid tailings volume profile** | The forecasted accumulation and reduction of fluid tailings volumes for each year to end of mine life. |
| **Indicator** | An indicator is a measurable variable that is strongly correlated with the condition of a component that is tied to a specific objective or outcome.<br>Measurement of indicators provides evidence that a certain condition exists or certain results have or have not been achieved. |
| **Legacy equivalent volume** | A volume of fluid tailings equivalent to the volume of fluid tailings in storage before January 1, 2015. |
| **Legacy tailings** | Fluid tailings in storage before January 1, 2015. |
| **Limit** | Clear boundaries not to be exceeded. |
| **Measure** | A qualitative or quantitative aspect of an indicator; a variable which can be measured (quantified) or described (qualitatively) and demonstrates either a trend in an indicator or whether or not a specific criteria was met. |
| **New fluid tailings** | Fluid tailings created on or after January 1, 2015. |

| | |
|---|---|
| **Profile** | New and legacy fluid tailings volume inventory profile. |
| **Profile deviation trigger** | Alerts operators and regulators when the volume of fluid tailings is growing faster than originally approved. Additional management action is required when the profile deviation trigger is exceeded. |
| **Project** | A mining operation that is the subject of an approval under the *Oil Sands Conservation Act*. The term "project" is used synonymously with "scheme," "approval," or "operation." |
| **Ready to reclaim (RTR) (fluid tailings)** | State achieved when fluid tailings have been processed through an accepted technology, have been placed in their final landscape position, and have achieved necessary performance criteria. |
| **reclamation activities** | Include activities that support permanent reclamation, such as landform construction and contouring, clean material placement (where necessary), reclamation material placement, and revegetation. |
| **Reclamation criteria** | A category of conditions or processes by which the achievement of a reclamation objective is assessed. A criterion (singular) is characterized by one or more related indicators that are used to determine success or to assess change over time. |
| **Robustness** | The degree to which a technology operates correctly in the presence of exceptional inputs or stressful environmental conditions. |
| **Subobjective** | The objective is broken down into more detail, creating a set of subobjectives, such that meeting all subobjectives leads to the completion of the objective. |
| **Tailings** | A mixture of sand, clay, water, silts, residual bitumen, and other hydrocarbons, salts, and trace metals. This definition is used synonymously with the *Oil Sands Conservation Rules* definition of tailings as a by-product of the bitumen extraction process including water and sands, fines or residual bitumen or other hydrocarbons or any combination of those things. |
| **Thresholds** | Triggers and limits within the management framework system. |

| | |
|---|---|
| **Total volume limit** | A volume of fluid tailings that presents an unacceptable risk to the environment and potential long-term liability. Exceedance of this limit will compromise the ability of an operator to have all of their fluid tailings in an acceptable management (RTR) state by ten years after the end of mine life. Therefore, the most severe management responses are initiated when a limit is exceeded. |
| **Total volume trigger** | Indicates that the volume of fluid tailings has exceeded its approved maximum accumulation and requires additional management action. |
| **Trigger** | Warning signal to allow for evaluation, adjustment, and innovation on an ongoing basis. |

## Appendix 2 Example Derivation of RTR Performance Criteria

### Objective

The RTR performance criteria must be appropriate to ensure that fluid tailings are on a trajectory to successfully support future stages of reclamation activity. This is intended to minimize the need for continuous management of risks.

The RTR performance criteria must align with the next steps of reclamation to successfully support reclamation towards a self-sustaining, locally common boreal forest ecosystem that is consistent with the values and objectives identified in local, regional, and subregional plans and integrated with the surrounding area. It must do the following:

- Identify the targeted range of ecosites proposed for reclamation objectives for each operating deposit (must be consistent with previously identified ecosites in the mine reclamation plan or mine closure plan).
- Identify cap material and assess thickness cap requirements proposed to minimize effects on the surrounding environment based upon tailings composition and ecosite requirements.
- Identify reclamation material placement thickness to ensure that the RTR performance criteria align with the estimated final reclamation criteria.

### Example for Subobjective #1

- Place deposit to provide substrate for deposit capping material.
- Identify placement method considerations (i.e., hydraulic or mechanical placement).
- If additional consolidation will take place before capping, estimate the rate of consolidation and the timeframe capping is to be placed.
- Identify the degree of additional consolidation the capping will contribute to consolidation for reclamation material placement.

#### Example Indicators

- Material properties
- Residual settlement
- Trajectory to trafficability

#### Example Measures

- Solids content
- Sand to fines ratio
- Cone penetration testing program
- Estimation of residual settlement from excess pore pressure profiles

### Example Criteria

- Identify the minimum values for the measures. Where a progression of values is required in order to progress towards the next stages of reclamation, identify the trajectory of the values and identify the timeframe in which the values are to be met to meet the trajectory.
- Demonstrate how the proposed values align with and progress towards the next stages of reclamation.
- Minimum and Overall Solids to Fines Ratio > ***VALUE***
- Solids Content on a trajectory from ***VALUE%*** to ***VALUE%*** solids, by ***DATE***

By ***DATE***, trafficable by equipment required for capping or landform construction, as assessed by the ***VALUES*** for the following ***measures***.

## Appendix 3 Accounting

Operators must submit their site-wide fluid tailings inventory as per the table below.

| Year | Previous Year New FT Inventory | Previous Year Legacy FT Inventory | Fluid Tailings Inventory | Change in New FT Inventory | Change in Legacy FT Inventory | New FT Inventory | Legacy FT Inventory | Approved Profile New FT Inventory | Approved Profile Legacy FT Inventory | New FT Rolling Profile Deviation | Legacy FT Rolling Profile Deviation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | | | |
| 1 | | | | | | | | | | | |
| 2 | | | | | | | | | | | |
| 3 | | | | | | | | | | | |
| 4 | | | | | | | | | | | |
| 5 | | | | | | | | | | | |
| 6 | | | | | | | | | | | |
| 7 | | | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |
| 10 | | | | | | | | | | | |
| 11 | | | | | | | | | | | |
| 12 | | | | | | | | | | | |
| 13 | | | | | | | | | | | |
| 14 | | | | | | | | | | | |
| 15 | | | | | | | | | | | |
| 16 | | | | | | | | | | | |
| 17 | | | | | | | | | | | |
| 18 | | | | | | | | | | | |
| 19 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |

### Previous Year New FT Inventory

- Definition: Volume of new fluid tailings (FT) from the previous reporting period.
- Formula: This will be the same volume as the "New FT Inventory" for the previous year.

### Previous Year Legacy FT Inventory

- Definition: Volume of legacy fluid tailings from the previous reporting period.
- Formula: This will be the same volume as the "Legacy FT Inventory" for the previous year.

### Fluid Tailings Inventory

- Definition: Total volume of fluid tailings measured in treated tailings deposits or fluid tailings ponds, excluding any volume that meets specific RTR criteria at time of measurement (details on all RTR volumes, including those not in treated tailings deposits or fluid tailings ponds and measured volumes are provided separately). This value is also the sum of the actual new FT inventory and actual legacy inventory that will be compared to the approved profile FT inventories.

### Change in New FT Inventory

- Definition: The change in new fluid tailings volume over the year. Positive values indicate increase in FT volume; negative values indicate a decrease in volume.

### Change in Legacy FT Inventory

- Definition: The change in legacy tailings volume over the year. Positive values indicate increase in FT volume; negative values indicate a decrease in volume.

### New FT Inventory

- Definition: Volume of new fluid tailings at the time of measurement. This forms the starting point for the next year's reporting.
- Formula: [Change in New FT Inventory] + [previous year's "New FT Inventory"]

### Legacy FT Inventory

- Definition: The volume of legacy tailings at the time of measurement. This forms the starting point for the next year's reporting.
- Formula: [Change in Legacy FT Inventory] + [previous year's "Legacy FT Inventory"]
  The sum of the New FT Inventory and Legacy FT Inventory must equal the Fluid Volume Inventory.

## Appendix 4 COSIA's *Guidelines for Determining Oil Sands Fluid Tailings Volumes*

# Guidelines for Determining Oil Sands Fluid Tailings Volumes

Canada's Oil Sands Innovation Alliance

June 2015

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## 1. Introduction

In 2009 the Alberta Energy Regulator (AER) implemented Directive 074 (D074). The main objective of the directive was to reduce the inventory of fluid fine tailings (FFT) across various leases of the mineable Athabasca oil sands. In response to the directive, operators implemented a variety of site specific tailings measurement methods to monitor progress towards meeting the regulatory requirements.

The industry realized that such a variety of measurement and reporting methods could create differing approaches in estimating fluid tailings volumes as well as tailings performance. To introduce consistency in reporting, the Canadian Oil Sands Innovation Alliance (COSIA) was asked to evaluate the technical merits of various measurement techniques, and propose a set of industry recommended practices.

To meet this need the COSIA Tailings Environmental Priority Area (EPA) tasked the Tailings Measurement Steering Committee (TMSC) to produce these recommended practices. The scope developed into four areas of focus, including; Fines measurement, FFT Volume determination, Deposit Characterization, Sampling and Geostatistics.

In March 2015, the Government of Alberta issued the *Tailings Management Framework for the Mineable Athabasca Oil Sands* (TMF) as a component of the *Lower Athabasca Regional Plan 2012–2022* (LARP). These policy documents aim to provide *direction to manage fluid tailings volumes during and after mine operation in order to manage and decrease liability and environmental risk resulting from the accumulation of fluid tailings on the landscape*. With the issuance of the TMF, the Alberta Energy Regulator (AER) was sanctioned to bring the policy direction into force through regulations.

A key feature of the TMF is that each operator is required to submit a plan for managing fluid tailings including a volume profile of fluid tailings to be reclaimed during active mining and at mine closure. The fluid tailings volume working group considered the potential implications of the policy statements contained in the TMF when developing this final report submission to the TMSC.

## 2. Purpose

This guideline sets out procedures for determining the volume of fluid tailings contained within tailings deposits. It is intended to provide guidance to operators of oil sands mines to meet the objective of controlling fluid tailings volumes to an approved plan consistent with the TMF and as outlined in *Guidelines for Performance Management of Oil Sands Fluid Fine Tailings Deposits to Meet Closure Commitments*.[1] The background, rationale and objectives to plan and control fluid tailings volumes are set out in that document and related COSIA guidance

[1] *Guidelines for Performance Management of Oil Sands Fluid Fine Tailings Deposits to Meet Closure Commitments*. Canada's Oil Sands Innovation Alliance (COSIA), February 2014.

documents.[2,3] This guideline relies on the definitions included in those documents. It is aimed at standardizing sampling and measurement of fluid tailings including the fluid fine tailings in conventional tailings settling ponds as well as treated deposits that may have significant coarse sand content but are still in a fluid state.

## 3. Fluid Tailings Volume

In a tailings deposit, the volume of fluid tailings lies between two defined surfaces: the top of the fluid tailings or mudline (typically around 5 per cent solids), and the solid bottom of the deposit. (See Figure 3-1: Typical Fluid Tailings Deposit Profile.)

In a fluid tailings deposit covered with a layer of water, the mudline lies within the transition zone between the upper water layer and the underlying fluid tailings. The transition zone is usually distinct and occurs over a short distance of less than 20 centimetres (cm). The mudline depth is determined using sonar surveys or density plate surveys, and then verified using interval depth sampling.

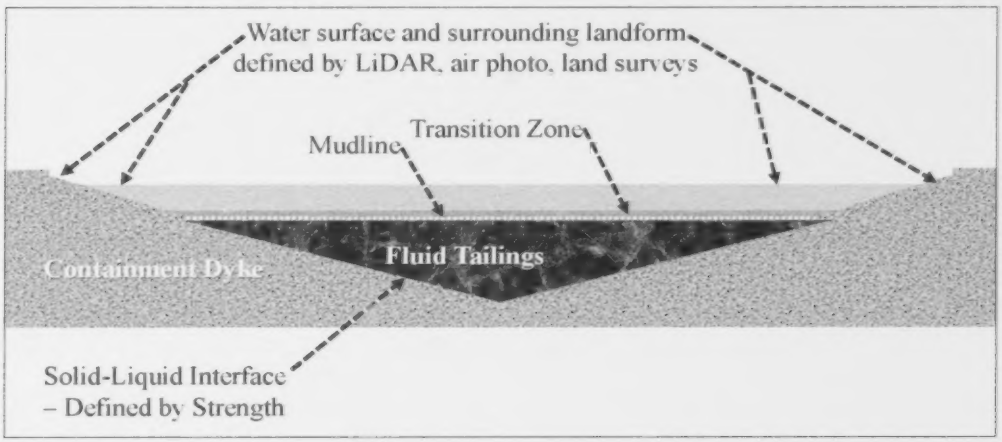


**Figure 3–1: Typical Fluid Tailings Deposit Profile**

The methods for determining the mudline depth in a water covered deposit described herein are based on ponds with a narrow transition zone from clear water to fluid tailings. In a fluid tailings deposit with no substantial surface water layer, the mudline is effectively the top of the deposit. Under this circumstance the top of the deposit can be measured using airborne or land based LiDAR, air photo surveys, or traditional land survey techniques.

The bottom of the fluid tailings deposit is defined by a surface representing the transition from fluid to solid. The transition can be sharp, for example where the fluid tailings meet a sand beach, or more gradual, such as in a consolidating tailings

[2] *Technical Guide for Fluid Fine Tailings Management*. Oil Sands Tailings Consortium/COSIA, August 2012.
[3] *A Guide to Audit and Assess Oil Sands Fluid Fine Tailings Performance Management*: Canada's Oil Sands Innovation Alliance (COSIA), May 2014.

deposit. The bottom of the fluid tailings layer is determined using drop sounding tools and cone penetration tests.

Once the top and bottom fluid tailings surfaces and the spatial coordinates of the containment structure have been determined, the volume of fluid tailings can be calculated using commercially available 3-D modeling software.

## 4. Measuring the Mudline

Four methods are used to define the mudline surface for a fluid tailings deposit:

### 4.1 Sonar Surveys (water covered deposit)

A fish finder is mounted on a boat and continuous depth and GPS location readings are recorded as the boat travels across the pond.

### 4.2 Density Plate Measurement (water covered deposit)

A density plate calibrated to the target density of the fines in water is lowered from a boat, the depth at which the plate stops is measured.

### 4.3 Interval Depth Samples (water covered deposit)

Physical samples are taken at measured intervals (10 cm) and analysed for solids content.

### 4.4 Land Survey Techniques (deposit without overlying water)

In a fluid tailings deposit that has no substantial water layer, the mudline is effectively the top of the deposit. In this case, the top of the deposit is measured using standard airborne or land based LiDAR, air photo surveys, or traditional land survey techniques.

For water covered deposits, the mudline depth is measured using either sonar surveys or density plate surveys. In both cases, the measurements are validated using interval depth sampling.

Further details of current practice for the three water covered methods are provided in the Appendices A, B and C.

## 5. Measuring Hard Bottom

Two methods are used to define the hard bottom interface of fluid tailings deposits:

### 5.1 Drop Soundings

With a drop sounding tool, the bottom of the fluid tailings is determined by dropping a heavy weight probe from a boat and recording the depth to the hard bottom when the weight stops.

### 5.2 Cone Penetration Testing (CPTs)

With CPT, a cone on the end of a series of rods is pushed into the tailings deposit at a constant rate while continuous measurements are made of the

resistance to penetration of the cone and of a surface sleeve. The fluid tailings bottom surface is determined based on resistance measurements.

Drop sounding measurements are validated with selective CPT measurements. When dense bitumen mats or debris cause difficulties with drop sounding, the CPT tool is used in conjunction with drop soundings to get the hard bottom interface. Appendices D and E provide further details on the two methods.

## 6. Acknowledgements

This guideline was prepared by the COSIA Tailings Measurement Working Group whose members were Paul Cavanagh (chair), Robert Donahue, Al Hyndman, Adam Langer, Bruce Li, Wayne Mimura and Sean Wells. COSIA would also like to thank David Baldrey of Total and Andrea Larson of the AER for their review and guidance on the document preparation.

# Appendix A Sonar Survey

For water covered deposits, surveys to determine the mudline surface are conducted with the use of a sonar GPS recording instrument. A commercial sonar tool (fish finder) is commonly used in the oil sands industry. This utilizes sonar signals to measure recycle water depth to the tailings beach or to the top of the fluid tailings deposit, whichever comes first.

Sonar (SOund NAvigation and Ranging) uses high frequency sound signals (~ 200 Khz) to determine the depth of water by measuring the time it takes for an emitted sound signal to bounce off the bottom or interface and return to the transducer.

The advantage of sonar is that it provides a continuous surface trace across the transection of the pond. Sonar reflection is intended to detect the mudline. However, the mudline is not a distinct surface so reflection may occur over a range of solids contents (typically less than 5%). As a result, the sonar depth reading is validated at several locations by interval sampling as described in Appendix C. The number of interval samples required depends upon the consistency of readings and the uniformity or variation of the mudline surface elevation.

Sounding locations should transect the fluid tailings deposit. The lateral extent of the fluid tailings terminates at the intersection of the mudline with the bottom of the pond containment – for example, a sand dyke beach. Depending upon the overlying depth of water and the slope of the containment beach, different methods may be necessary to define the perimeter intersection of the fluid tailings with the beach.

For each sonar survey the following data are recorded:

- The depth of the sonar transducer below the water surface. (Typically the transducer is at the surface or assumed to be at constant depth below the surface, but may be affected by wind induced wave action or by the speed of the vessel over the water. Ideally, surveys are conducted in calm weather without wave action.)
- The XY location of the sonar transducer relative to its position on the water.
- The GPS coordinates of each sounding.
- The elevation of the water surface.
- The sound pulse frequency (typically 200 kHz).
- Alignment of the transducer. The sonar signal should be transmitted down vertically to ensure accurate delineation of the mudline. Any deviations from the vertical are recorded.

## Appendix B Density Plate Survey

A density plate survey is conducted using a plate of a calibrated density which has neutral buoyancy at the mudline.

A density plate is a plastic plate with an area of approximately 3600 $cm^2$ and a thickness of 25 mm. (See Figure B-1: Density Plate Schematic). The plate has symmetrically placed holes that are used to hold stainless steel bolts and nuts. The bolts and nuts are used to ballast the plate so that it has a density equivalent to water with 5% solids content (1.032sg approx. depending on temperature of fluid). A thin stainless steel wire is attached to each corner of the plate. These wires meet in the middle of the plate at a height of about 20 cm. At this point the support and depth measuring wire is attached, with the zero point of the measuring wire referenced to the mid-thickness of the plate. The wire is marked at 0.25 m intervals for measurement reference.

The density plate is calibrated at least once a year. The plate is suspended in a saltwater solution beginning with of 20 litres (L) of water containing 800 grams (g) of dissolved salt. Salt is added until the plate reacts. The plate should float in a 55 g/L solution and sink in a 45 g/L solution. Calibration is performed with wires attached, imitating field testing methods. Ballast in the form of stainless steel nuts, bolts, and screws is added or removed until the plate is fully submerged and floating freely in the solution.

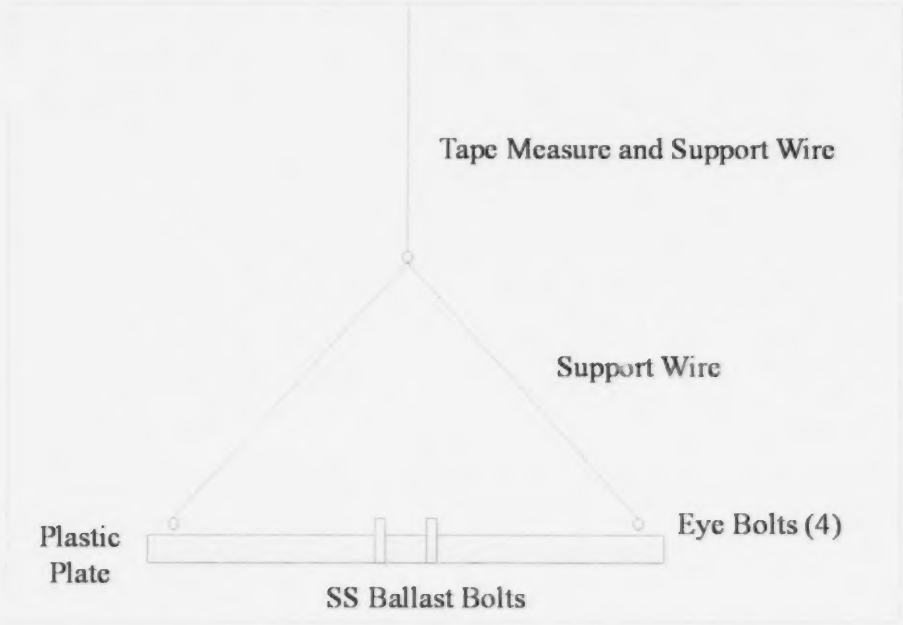


**Figure B-1: Density Plate Schematic**

At each survey point, the measurement platform (e.g., boat, barge) must be stationary, allowing the platform to position itself for two to three minutes to minimize the effects of current and wind. Movement that causes the wire attached to the density plate to deviate from vertical affects the accuracy of the measurement. The greater the depth of the mudline, the greater the error will be.

At each survey point, the plate is placed in the water on a horizontal plane. The plate is allowed to sink under its own weight until it stops. Once the plate has stopped, it is slowly raised by 1 cm to 2 cm, and then allowed to fall again. If the second measured depth deviates by more than 1 cm from the first, the test is repeated.

A number of factors can complicate the use of the density plate and the determination of the mudline:

- Crimps in the depth measuring wire may occur and cause errors in the mudline depth measurement. To prevent this, crimps or kinks in the wire are smoothed out.
- Accumulated debris or bitumen on the density plate will skew measurement of the mudline depth. The plate is cleaned after each use. Areas with surface accumulation of bitumen are either avoided or the bitumen cleared away before the test.

While the sonar method provides a continuous trace of depth across each transection, the density plate provides only spot measurements. Therefore, the number of measurement points needed to define the surface is a function of the mudline depth variation and its impact on the total fluid tailings volume determination.

The apparent depth of the mudline, determined by density plate measurements, is validated at a minimum of three locations across the tailings deposit by interval sampling as described in Appendix C.

## Appendix C Interval Sampling

Interval sampling is used to validate the measurements generated by sonar or by density plate surveys. At each location, the solids content of samples taken at the mudline and at 10 cm intervals 0.5 m above and below the mudline is determined. The mudline is the transition from clear water to fluid tailings, where the suspended solids content in the water increases by ≥ 5% solids content over a 10 cm interval. (See Figure C-1: Confirmation of Mudline using Interval Sampling.)

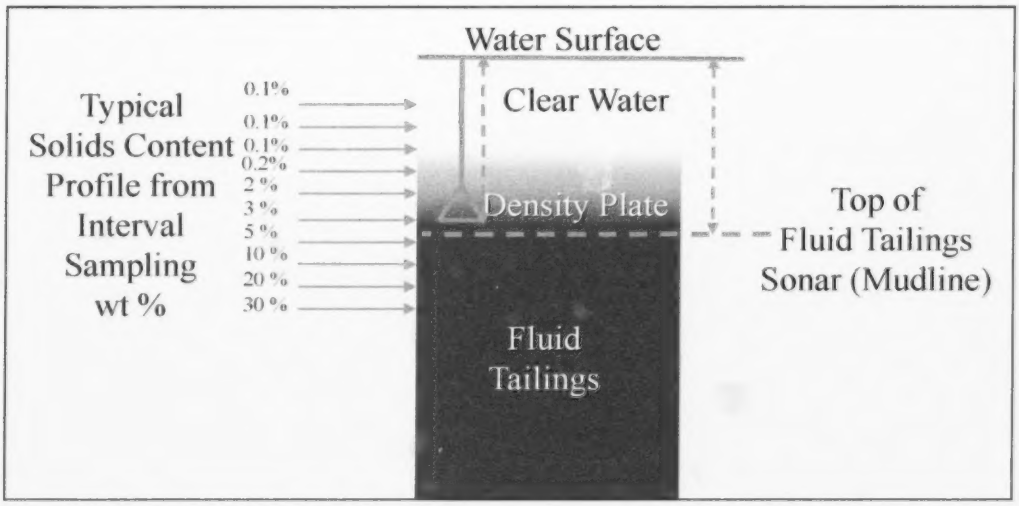


**Figure C-1: Confirmation of Mudline Using Interval Sampling**

# Appendix D Drop Sounding

Drop sounding is a rapid method of determining the bottom surface of the fluid tailings layer and is typically used to profile soft tailings deposits. It works best in tailings deposits with sharp transitions between fluid tailings and hard bottom (sand or overburden).

The drop sounding tool is deployed from a platform using a winch line that is calibrated to measure depth. The sounding tool is allowed to drop freely at the slower of the winch speed (maximum of 1 m/s) or the maximum dropping speed of the sounding tool. If the deposit becomes thick, the drop speed slows and the winch speed is adjusted to follow. When the sounding tool stops moving (refusal point, defined as less than 5 cm over a 30 second period), the bottom of the fluid tailings layer has been found, the test is terminated and the sounding tool is retrieved.

The schematic for design of an acceptable drop sounding tool to determine oil sands pond bottoms is shown in Figure D-1: Drop sounding Tool Schematic.

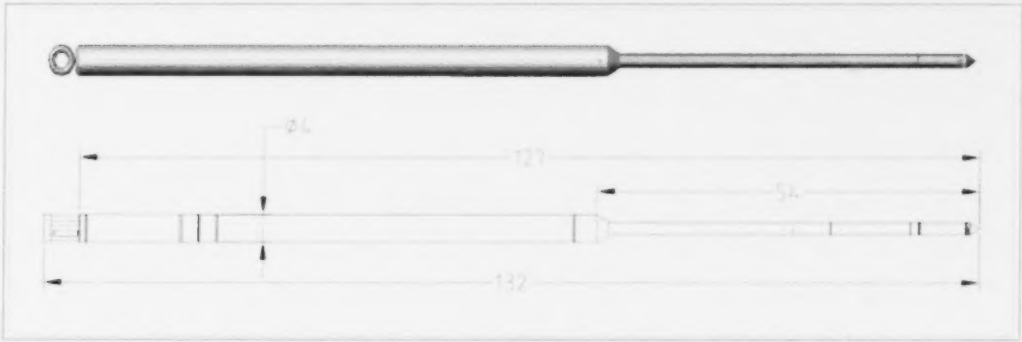

**Figure D-1: Drop sounding Tool Schematic**
(Dimensions in inches)

General specifications for a drop sounding tool are:

- 300 lb. total weight
- 132 inches long
- 4 inch diameter weighted section decreasing to 1.75 inches for the last 54 inches of length
- A Piezocone penetrometer capable of measuring inclination, pore pressure (U2), and tip resistance forms the end of the tool (not a mandatory requirement but beneficial).

The deployment platform must be stationary. Platform drift causes non-vertical deployment of the sounding tool resulting in depth measurement errors. The maximum drift of the deployment platform should be no greater than 5 % of the recorded depth of the sounding.

The following data are recorded for each sounding location:

- Pretest GPS coordinates
- GPS coordinates of refusal point
- Depth of refusal point
- Drop time to refusal point
- Drift of drop sounding tool
- Pond surface elevation.

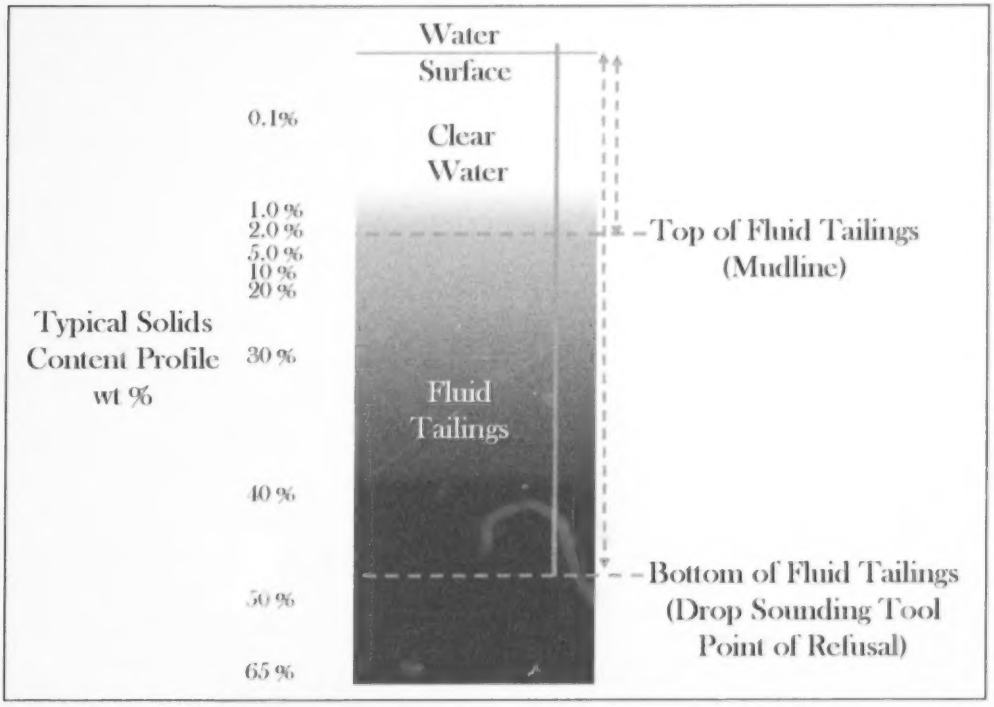


**Figure D-2: Bottom of Fluid Tailings Measurement**

A number of factors may complicate the use of the drop sounding tool and determination of the bottom surface of the fluid tailings layer:

- In tailings deposits where the solids content is increasing (e.g., CT), or with significant bitumen content, the drop sounding tool may stop due to other factors including skin friction, tip resistance, or viscous strength effects.
- Floating muskeg or bitumen mats may cause the tool to prematurely refuse. Several drops in the same location may punch through the obstruction, but this may not always be successful.
- In areas of interlayered hard and soft zones, the drop sounding tool will stop at the first hard zone and the true bottom of the fluid tailings layer will not be recorded.

Therefore, the estimated bottom of the fluid tailings layer is validated with CPTs. The number of CPTs required depends upon the consistency of the hard bottom surface

readings. Other methods such as sampling, vane shear testing, tailings behavior type, passive gamma, and full-flow penetration testing may be used to verify the location of the bottom of the fluid tailings.

For each type of tailings material encountered during drop sounding (sand, CT, thickened fines, froth tailings, coke, overburden), CPTs are conducted at selected locations to validate the drop sounding measurement of pond bottom.

# Appendix E Cone Penetration Test

In areas where the tailings deposit limits the use of a drop sounding tool (e.g., subaerial deposits), or where the drop sounding measurements must be verified, the bottom surface of the fluid tailings layer is determined using CPTs. With CPT, a cone on the end of a series of rods is pushed into the tailings deposit at a constant rate. Continuous measurements are made of the resistance to penetration of the cone and of a surface sleeve. The fluid tailings bottom surface is determined based on resistance measurements.

A cone penetration test with pore pressure measurement (CPTu) is conducted following ASTM D 5778-12. Pore pressure measurements are conducted with the piezometer in the U2 position (behind the shoulder of the cone). For a Ball-CPTu, ASTM D5778-12 is followed along with modifications suggested by Dejong (2010)[4]. This entails locating the pore pressure measurement at the equator of the ball, with a penetration rate of 0.2 to 0.3 diameters per second with appropriate calibration and recording measurements conducted on both extraction and penetration of the ball

The fluid tailings bottom is determined by measuring the net CPTu tip resistance. In a CPTu, the undrained shear strength in a deposit can be determined as follows:

$S_u = q_{net}/N_{kt}$

Where:

$S_u$ =undrained shear strength

$N_{kt}$ = cone factor

$q_{net}$= net tip resistance (This factor is calculated differently for ball and cone but is essentially a measure of the measured tip resistance, corrected for pore pressure effects and subtracting the overburden stress.)

The main source of uncertainty in interpretation from deposit to deposit lies in the selection of the cone factor. Assuming a standard cone factor for all deposits, while simplistic, eliminates this issue in interpretation. $N_{kt}$ for the ball is usually between 10 and 11 and $N_{kt}$ for a cone is usually between 14 and 15.

Therefore the fluid tailings bottom surface can be defined as the point where $q_{net} < 75$ kPa for measurements with a cone tip and $q_{net} < 55$ kPa for measurements with a ball tip.

Solid bottom determinations by CPT measurements are based roughly on peak undrained shear strength greater than 5kPa.[5]

[4] DeJong, J.T., Yafrate, N.J., DeGroot, D.J., Low, H.E., and Randolph, M.F. *Recommended Practice for Full-Flow Penetrometer Testing and Analysis*, ASTM Geotechnical Testing Journal, 2010, Vol. 33, No. 2, pp. 137-149.

[5] The peak undrained shear strength of 5kPa represents an approximation to the liquid limit of a cohesive deposit.

The following factors are taken into account when generating high quality CPTu data:

- Selecting a suitable load cell capacity (full scale output)
- Stringent load cell calibration at the low end of the scale
- Minimizing transient temperature effects
- Measuring zero load stability and drift
- Recognizing the effect of soil layers ahead of and behind the penetrating cone (typically about 4 times the cone radius for depth effects in soft soils).

The interpretation of CPT data including its correlation with drop tool soundings, and where appropriate, the selection of the $N_{kt}$ value, is carried out by experienced personnel having familiarity with the depositional environment in which the soundings were obtained. It is considered prudent to interpret the CPT data in conjunction with other available relevant data (e.g., particle size distributions, deposition environments, etc.) to identify false bottoms or to characterize deposits where the measured pond bottom appears to be above the original pond bottom.